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Oct. 1, 1964

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is pleased to submit the enclosed unsolicited proposal for a Multiple Image Correlator. The proposed program will result in equipment delivery within 8 months from initiation of contract.

As a part of the program we also will supply the customer with monthly progress reports and a final report. Reproductions of all sketches used in manufacture will be furnished if requested. If the customer desires formal drawings, a separate quotation will be made.

The total price, fob-Hawthorne, California, for the procurement 25X1

In addition to this first article price, we have also estimated the price of ten additional units at each. 25X1

This quotation is valid for 60 days from October 1, 1964.

Yours truly,

25X1

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cc:5
enc.

PROPOSAL

for a

MULTIPLE IMAGE CORRELATOR

Presented By

[redacted]

25X1

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1. Introduction

The subject of Multiple Image Correlation is one which has interested the entire photographic reconnaisance and intelligence community for the past several years.

Unfortunately, it has been an area in which far too much experimentation and device construction took place before a solid theoretical understanding was achieved, and as a consequence there was no method of data synthesis. The history of science is full of instances where experimental data collection did not contribute to understanding of physical phenomenon until theoretical models were developed for data evaluation.

The first theory specifically addressed to multiple image correlation was presented at the American Optical Society in 1963 by Dr. Jack Robe [redacted] These theoretical results are discussed in Section 2. 25X1
The interesting aspect is that no one at the meeting seemed to grasp all of the implications -- indeed even since that time some people have continued to mouth the same old platitudes which characterized the field for the last four years. In large part some of this may be due to the fact that many people were so entrenched in their commitment to previous equipment and proposals for equipment that it was best to ignore the obvious consequences of Dr. Robe's theory and his presentation of experimental verification.

This proposal utilizes this theory to arrive at an equipment concept for an inexpensive, state-of-art performance Multiple Image Correlator. In addition several novel alternate uses for the equipment are mentioned which should be valuable tools in the photo interpretation business.

2. Theoretical Discussion

A detailed development of the theory can be furnished if it is of interest. A brief discussion of the assumption and results are given below. The principles are a part of modern photographic knowledge, viz:

(1) The resolving power of film is contrast limited

(2) At low contrast the dominant limitation on resolution is grain noise, i.e., statistical fluctuation of grain density. The final results are determined by a proper statistical interpretation of the photographic process

2.1 Contrast Limitations

The functional behavior of resolution as a function of exposure contrast can be represented* as:

$$R = R_\infty \left[1 - \left(\frac{1}{k}\right)^{\frac{\alpha}{2.3}}\right]$$

where:

k = exposure contrast = $\frac{E\ max}{E\ min}$

R_∞ = resolution at $k = \infty$

α = a constant $\simeq 2.3$

as a first approximation:

$$R = R_\infty \left[1 - \frac{1}{k}\right]$$

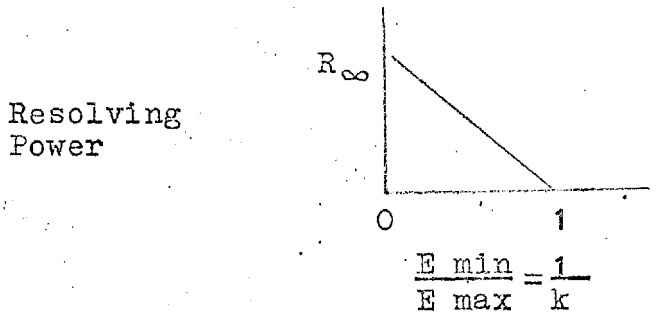
or:

$$R = R_\infty \frac{\Delta E}{E\ max} \qquad \Delta E = E\ max - E\ min$$

and the as $\Delta E \to 0$ $R \to 0$.

* Mees, The Theory of the Photographic Process, P 1012, Revised Edition, 1954

Thus, as contrast approaches zero so does the resolving power. A typical curve* is shown below:



2.2 Grain Noise Limitations

The physical limitations of resolution are:

(1) finite grain size

(2) scattering of light in the emulsion

(3) statistical fluctuation of grain density

Since grain sizes are typically .1 micron in ordinary films, one would expect photographic resolutions of the order of the grain half width or 1000 lines/mm. These emulsions have resolutions much less than this and thus it must be concluded that they are limited by processes (2) and (3). In the case of high contrast, the light is scattered from the "exposed" region into the adjoining regions and thus limits the achievable line spacing. This is technically referred to as the spread function limit.

Scattering distance is invarient with respect to exposure contrast and yet at low contrast the resolution goes to zero. Hence, it is apparent that low contrast resolution is limited by grain noise. Theory shows that for sufficiently low contrast the improvement in

* Mees, The Theory of Photographic Process, P. 1018, Revised Edition, 1954

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resolution obtained by correlating N photographs is N. At medium contrasts the improvement possible falls off to $\sqrt[3]{N}$ and eventually falls to zero at high contrast (1000:1). Figure 1 depicts the results to be obtained with a typical film such as

3. Equipment Implications

The above theoretical conclustion have some drastic implications concerning an optimum, i.e., most cost/effective Multiple Image Correlator design. In summary these are:

1-Expensive, special optics are not required

2-High precision multiple stages are not required

3-Electronic alignment is not required

3.1 Optical System

Commercially available optics are more than adequate. If magnification range on one channel is desired it can be accomplished with a commercial zoom lens. How about geometric matching? How about res fall off at periferry

3.2 Mechanical System

Once the determination of theoretical limitations is realized, it becomes obvious that commercially available ($300.00) stages are completely adequate. In addition the entire concept of sequential correlation becomes greatly eased, viz. such standard techniques as swinging mirrors are perfectly satisfactory.

3.3 Alignment System

It is true that electronic alignment techniques show promise of achieving greater accuracy and precision than the human eye. However, one never visually aligns on the extreme low contrast or high line number regions of a photograph. There are always some portions

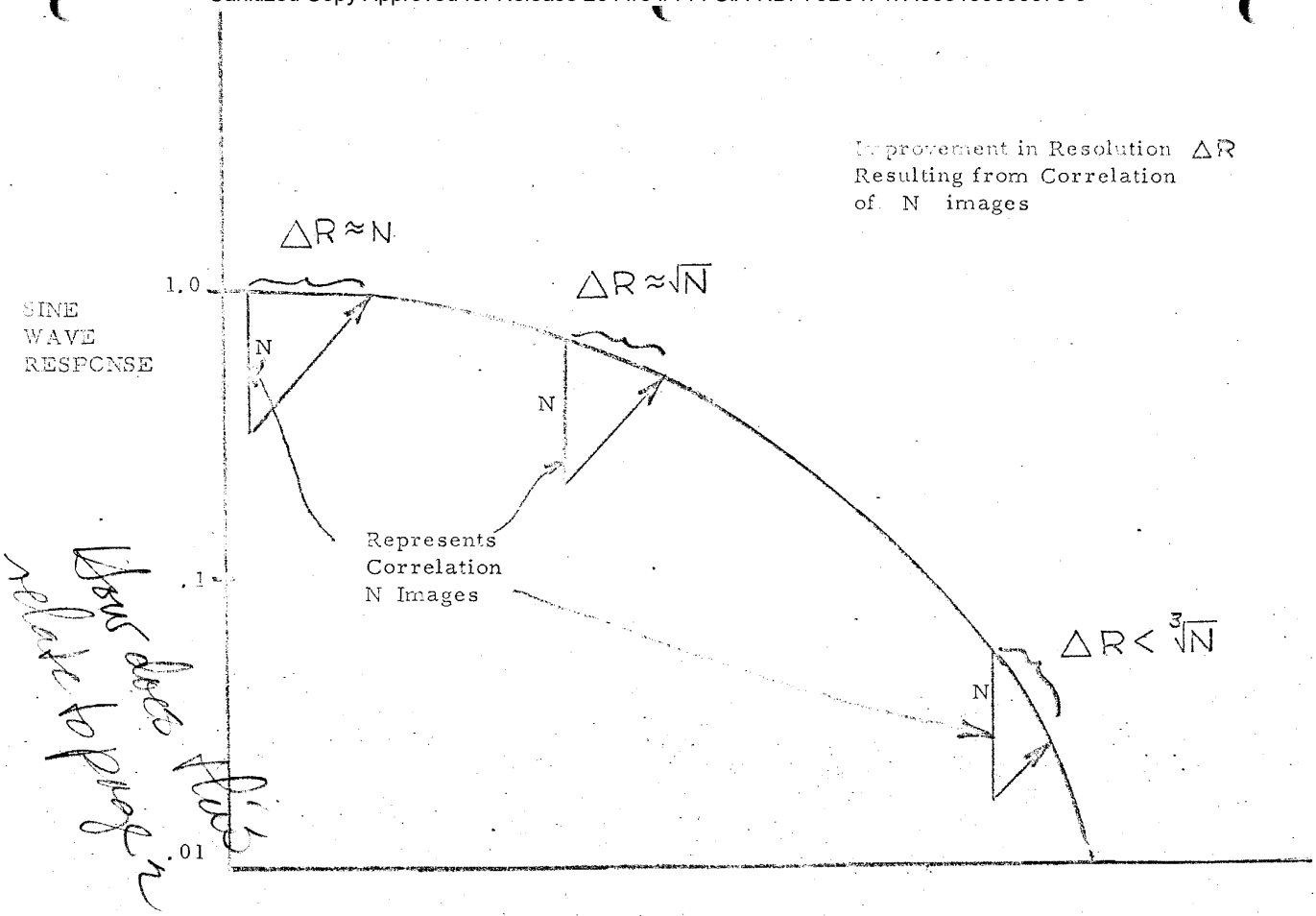

Figure 1 - SPATIAL FREQUENCY

ideally suited to eye alignment. The actual situation is one in which there probably is not a single person who will put money on the line that you can achieve better correlation with electronic alignment. It might happen with a very sophisticated and expensive system, but to date it has not been observed. (It is theoretically possible to obtain a high degree of alignment but theory proves that this doesn't insure additional correlation.)

4. Equipment Description

4.1 Configuration:

The proposed Multiple Image Correlator is depicted in Figure 2. It will be designed for table-top use with a weight of 100 pounds, and over-all dimensions of 24" wide, 18" deep, and 20" high. It will be highly portable. The viewer consists of two complete projection channels, a "precision" film alignment stage in one channel, a single screen for viewing and a 4" x 5" film for filming of the images which are superposed on the screen. The unit will also emphasize a clean appearance, easy access to all controls and a bright screen so it can be used in a normally lighted room.

at 25X this would be a .2" on original

4.2 Detailed Description

Figure 3 is a cut-a-way of the correlator. The major assemblies will be referenced from the base frame casting to maintain precise alignment of the optical systems. All of the optics are easily accessible for cleaning and other parts such as the light source are easily replaceable.

4.21 Film Platens

The film chip platens handle a maximum of 70/mm film chips. The film is held between spring loaded glass plates. A unique feature is that the entire platen assembly is easily removed since it is held by permanent magnets while in the projection position. As an alternate a 70 mm roll film platen can be supplied which accommodates up to 30 feet of film. The film drive will be manual and once the desired frame is selected, positioning is exactly as the case for chips. Figure 2 shows the platen assemble both in-place and separately.

4.22 Coarse Positioning

Both film chip platens are initially positioned by sliding the entire assembly relative to the steel backing plate at each projection station. The magnetic holding is weak enough to allow easy rotation and translation of the platens to the desired position relative to the optical axis. Once this film alignment is made a film platen lock device is actuated and the reference platen is firmly locked for sequential exposures. The reference or master channel is provided only with the coarse adjustment described above.

4.23 Fine Positioning

The adjustable channel i.e., the one in which the film chips are placed sequentially, has precision x, y, and θ adjustments. Accuracies of $\pm$ .0005 over $\frac{1}{2}$" in x and y and $\pm$ .01° over 5° will be maintained. Because of these high linear accuracies and since the stages are equipped with micrometers an ideal measurement tool is also provided as a bonus feature.

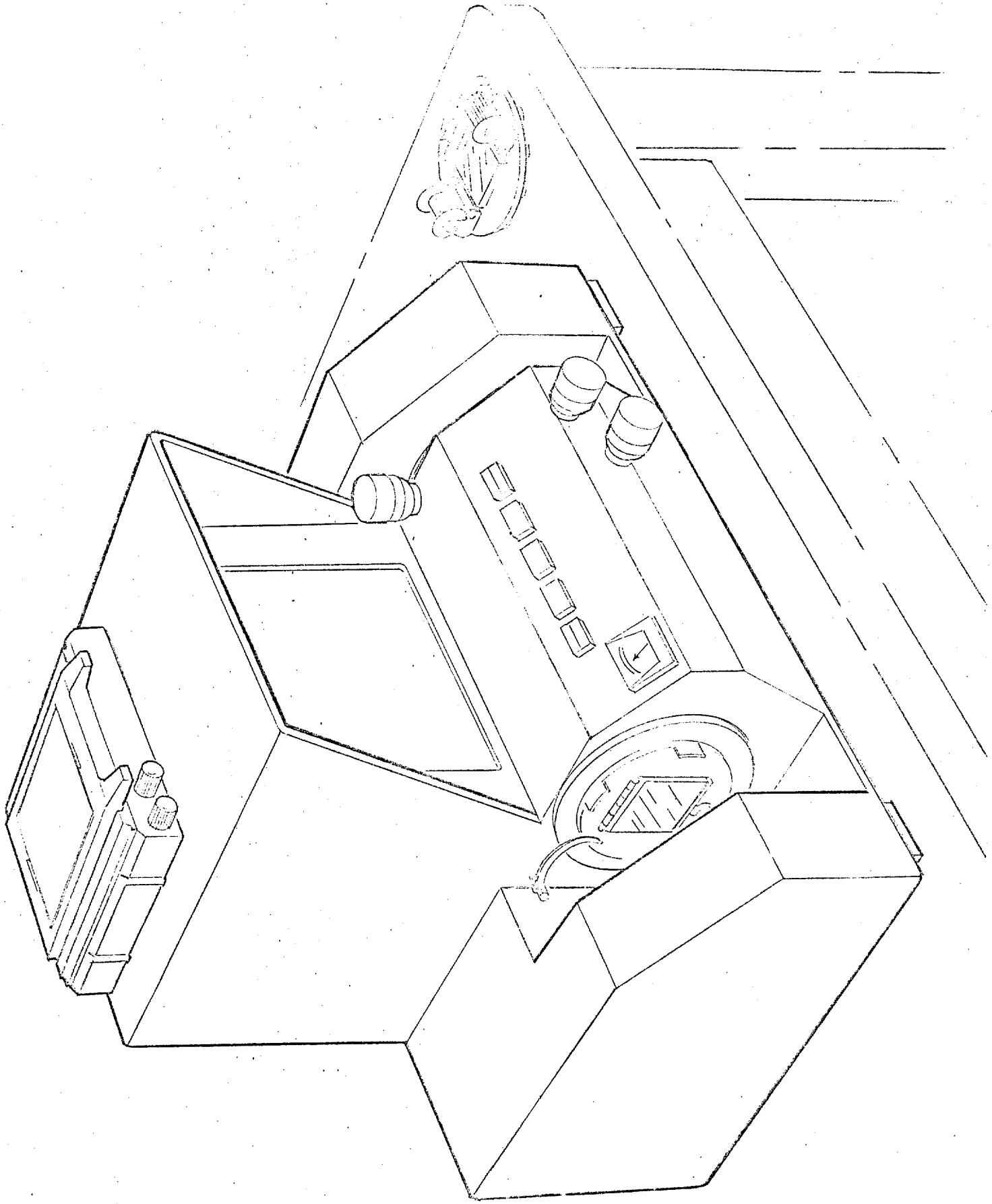

Figure 2 - External View

4.24 Optical System

Magnification: The system will operate with a matched fixed magnification of 25x in each channel. This magnification has been found excellent for visual alignment over the film resolutions for which multiple correlation is effective. Several commercial lenses of approximately one inch focal length are available. High resolution will not be a determining factor in selection - more attention will be given to abberations such as color.

Light Source: 300 watt tungston sources will be used in each channel in conjunction with a commercial 35 mm projection condensor such as manufactured by Argus and others. The channels will be adjusted so that their brightness is matched to within 5%.

Optical Superposition: Superposition of the two channels on the single viewing screen will be accomplished by the wedge mirror shown in Fig. 3. The off-axis condition which results should not cause difficulty and in any event could always be completely obviated by adding another mirror and a beam splitter to the system.

Screen: Since the console is designed for single operator use a high gain screen can be used. A gain of four has been selected. With the 300 watt lamp, the optical train and this gain an open film gate brightness on the screen of 150 foot-lamberts will be achieved.

4.25 Film And Plate Holder: On the top of the unit is a film holder which will accomodate standard 4" x 5" film plates, polaroid backs and any other standard 4" x 5" camera back accessories. A focal plane shutter built into this portion of the system provides for

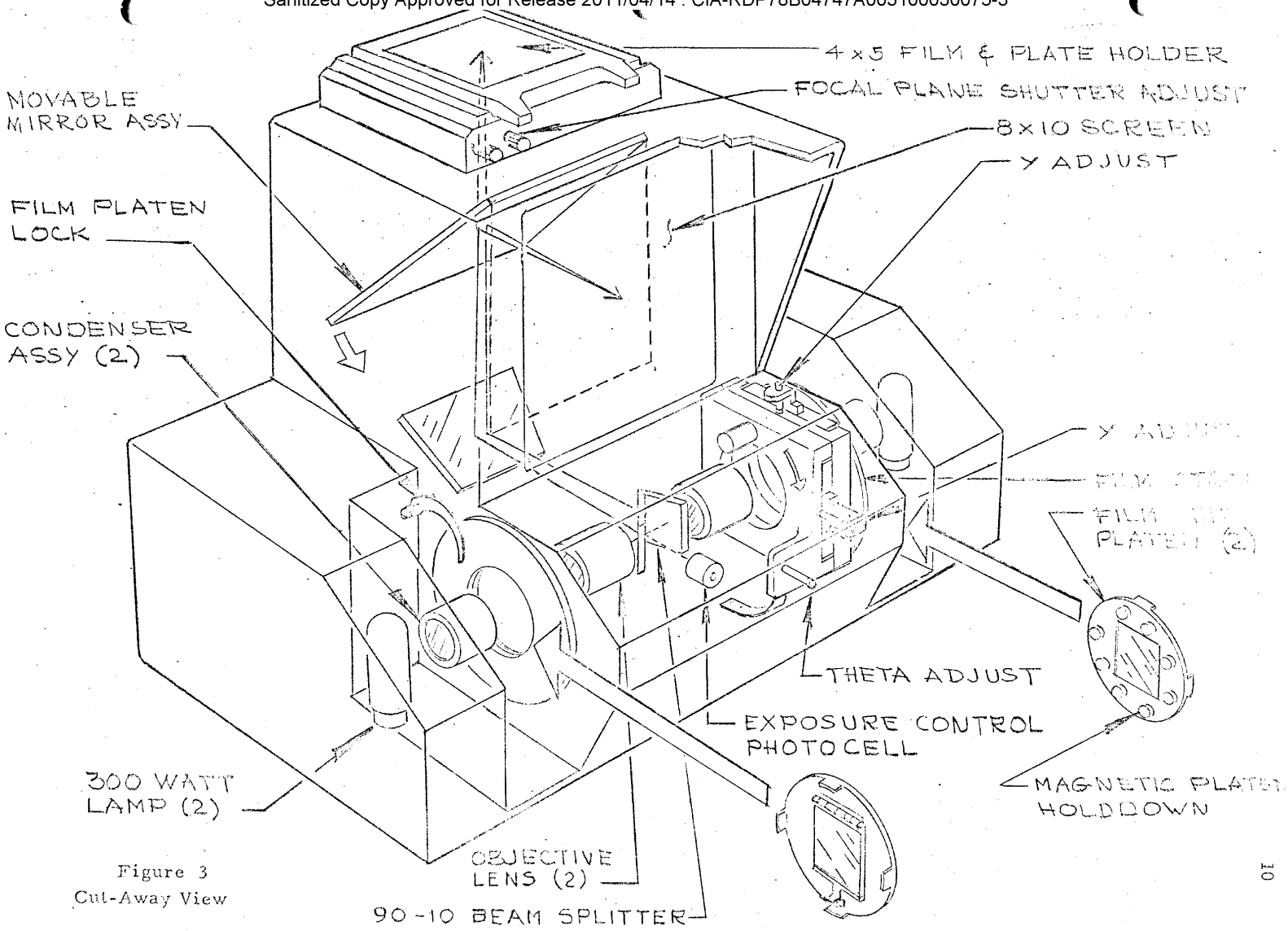

Figure 3
Cut-Away View

variable exposure for each frame to be photographed. A meter and photocell indicates the proper exposure for each frame of photography in the adjustable channel. true for sequential?

4.26 Controls: As shown in Fig. 2 all of the required controls are readily available to the operator. These are:

1-System ON-OFF

2-Channel 1 ON

3-Channel 2 ON

4-Channel 2 Blinker. This channel facilitates alignment of two channels

5-Mode indicator. This mode indicator shows the position of the moveable mirror assembly (either Project or Expose)

6-Exposure meter. The calibrated exposure control meter indicates the proper setting of the focal plane shutter speed for various film types.

5. Additional Uses for Proposed MIC

5.1 Spectral Difference Detection

Since the taking system could use filters for selective spectrums, the device would also be useful as a difference detector. As an example, suppose the same object were photographed with both IR and visual. By using the correlator it might be possible to determine the differences arising from camouflage, dead foliage, heat sources, etc. The same arguments are true for other spectral zones.

5.2 Color Recombination

If the taking system used normal color filters

the MIC could furnish a color output. This could be useful in situations where use of color film in the taking camera was prohibited because of low resolution.

5.3 Selective Spatial Frequency Correlation

Although it has not been tried to our knowledge a very interesting and potentially fruitful concept is to combine spatial filtering with multiple image correlation. Certainly it is a theoretically sound idea. Basically it amounts to limiting the bandwidth before the correlation process.

Used in this sense the proposed equipment would allow a wide range of experimentation to be performed in the emerging field of optical filtering.

5.4 Dodging Viewer-Printer

If unsharp masks are made of any take then by putting the mask in one station and the original in the other the final image is dodged. It may be viewed or printed at the option of the operator.

5.5 Stereo Viewer:

Stereo fusion by either polarization or color would be possible. This is not the most desirable stereo, but it is only suggested as an alternate use.

5.6 Summary of Alternate Uses

These various alternate uses may be collectively summarized as the potential of a two-stage superposition viewer. They may or may not prove fruitful in practice and are only suggested as potentials which can be inexpensively analyzed and exploited with only minor modifications of the recommended equipment.

6. Conclusions

[redacted] has presented an equipment design which will provide the government with an operational Multiple Image Correlator. The device is completely state-of-art, uses commercially available parts to a great extent and does not require sophisticated techniques for alignment and operation. Because of these factors it will have a low reproduction cost and will therefore be widely useable wherever the need arises. 25X1

7. Statement of Work

7.1 Scope

[redacted] will deliver a fully operating multiple image correlator to the following specifications 25X1

1-Superposition of any two film chips of size 3/4" diameter to 70 mm square format

2-Resolution of system at least 4 lines/mm AWAR on the screen

3-Screen brightness of single channel, open film gate, in excess of 200 foot-lamberts

7.2 Schedule

Delivery to customer within 8 months from start of project.

8. Capabilities

In addition to the principals, [redacted] has several associate consultants who are extremely talented in mechanical-optical equipment. We also have access to the part time services of many people employed in other companies. Resumes of both classes of help are included in the following pages. 25X1

BIOGRAPHIES

OF

PRINCIPALS

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BIOGRAPHIES OF

ASSOCIATE CONSULTANTS -and- PART-TIME CONSULTANTS

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